TITLE: Light NBC Protective Combat Suits and Body Hydration During Physical Activities Under Tropical Climate

TITLE: Blowing Hot and Cold: Protecting Against Climatic Extremes [Souffler le chaud et le froid: comment se proteger contre les conditions climstiques extremes]

Light NBC Protective Combat Suits and Body Hydration During Physical Activities Under Tropical Climate

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Summary

When wearing NBC protective suits in full protection mode, rehydration is fundamental to avoid large dehydration. However the gas mask constitutes a potential constraint for drink ingestion. The aim of this study was to evaluate in a hot country the effect of wearing different light NBC protective combat suits on body hydration during various physical activities.

In tropical country, six soldiers have performed moderate and sustained physical activities with different combat suits : standard battle dress and 4 light NBC protective combat suits in full protection mode. Moderate exercise consisted to walk at 4 km/h during 30 min under the sun. Then, subjects sat down under the shade for 30 min (recovery) during which spontaneous rehydration through the gas mask was possible. Sustained exercise consisted to perform the training run of the soldier. Rehydration was provided using imposed rehydration just after the run and rehydration *ad libitum* during the recovery.

During moderate exercise, the sweat rates were higher with TcNBCA and TcNBCB than with the other suits. After exercise, the PV decrease was higher with NBC suits than with standard battle dress. During recovery, the amounts of ingested water were lowered with NBC protective suits (through the gas mask) and were insufficient to correct the water losses and PV reductions. During sustained exercise, the sweat rates were twofold higher with NBC suits than with standard battle dress ($P<0.05$). The large PV decrease (about -6%) just after the run, whatever the suits, could rather be due to the intensity of exercise than to the water losses. Maximal amounts of water ingested through the gas mask after the run were small and insufficient to compensate efficaciously the fluid losses.

Our results have shown the importance of the fluid losses when wearing light NBC suits in full protection mode during various exercises in hot country. Rehydration through the gas mask was uneasy and did not allow to compensate effectively the water losses.

Introduction

The improvements of nuclear, biological and chemical (NBC) protection have allowed to develop light NBC protective suits which permit the combat in similar conditions than using standard battle dresses. However, in full protection mode (gas mask, gloves, hood in place) the body heat elimination is reduced and resulting dehydration can be very large. In these conditions, rehydration is fundamental but the gas mask constitutes a potential constraint for drink ingestion. The purpose of this investigation was to evaluate in a hot country the effect of wearing different light NBC protective combat suits on body hydration during various physical activities.

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Methods

Six soldiers from an operational group have participed to the experimental protocol in tropical country (Tair : 30-34°C, relative humidity : 55-75%). Each subject has performed 5 moderate and 5 sustained physical activities using different combat suits : standard battle dress (as reference) and 4 light NBC protective combat suits in full protection mode (TcNBC-O : charcoal impregnated compressed foam, Tc NBC-A : new charcoal impregnated compressed foam, Tc NBC-B : spherical particles, Tc NBC-C : activated charcoal cloth).

Moderate exercise consisted to walk at 4 km/h during 30 minutes under the sun. Before and after, subjects sat down under the shade of an open tent for 10 and 30 minutes (recovery) respectively. During the recovery spontaneous rehydration (mineral water) through the gas mask was then possible.

Sustained exercise consisted to perform the training run of the soldier (500 m and 20 obstacles). A recovery period of about 85 min was observed between each run in comfortable conditions (under the shade and wearing light clothing). Rehydration was provided using 2 modalities : imposed rehydration (maximal ingestion of water during 30 s through the gas mask) just after the run and rehydration *ad libitum* during the recovery.

Measurements. Before and after each test, subjects were weighed nude and urine was collected (volume, osmolality and density). Hematocrit, to estimate plasma volume (PV) variation, was obtained before and after each exercise, and at the end of the recovery. Heart rate (HR), and rectal and skin temperatures (Tre and Tsk respectively) were continuously monitored.

Results

During the tests comprising moderate exercise the sweat rates were higher with Tc NBC-A and Tc NBC-B than with other suits ($P < 0.05$). The time courses of Tre and Tsk confirmed the best results obtained with Tc NBCO and Tc NBC-C compared to the other NBC protective suits. After exercise, the PV decrease was higher with NBC suits than with standard battle dress ($P < 0.05$).

	SBD	Tc NBC-O	Tc NBC-A	Tc NBC-B	Tc NBC-C
sweat rates (ml)	**768 ± 139**	**815 ± 55**	**991 ± 32**	**895 ± 49**	**716 ± 65**
ingested water (ml)	**338 ± 67**	*** 248 ± 73**	**296 ± 84**	**286 ± 80**	**197 ± 68**
total dehydration (ml)	**429 ± 96**	**567 ± 81**	**646 ± 85**	**611 ± 98**	**519 ± 94**

Table 1 : Sweat rates, amounts of ingested water and total dehydration in six subjects after moderate exercise and recovery when wearing different combat suits : standard battle dress (SBD) and 4 light NBC protective suits.
$P < 0.05$ compared to SBD values ; + $P < 0.05$ compared to Tc NBC-O values;
$P < 0.05$ compared to Tc NBC-C values.

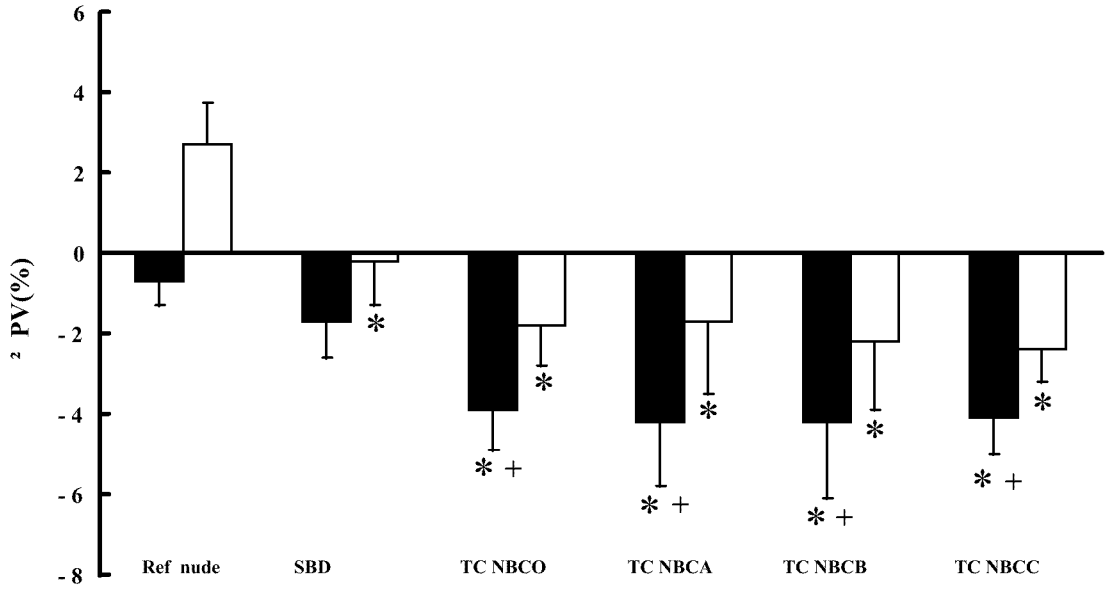

Figure 1 : Plasma volume variation ΔPV (means ± SEM) in six subjects after moderate exercise (.) and recovery (.) during reference test (Ref nude) and when wearing different combat suits : standard battle dress (SBD) and 4 light NBC protective combat suits (TC NBC-O, TC NBC-A, TC NBC-B, TC NBC-C).

* $P<0.05$ compared to Ref nude values ; + $P<0.05$ compared to SBD values.

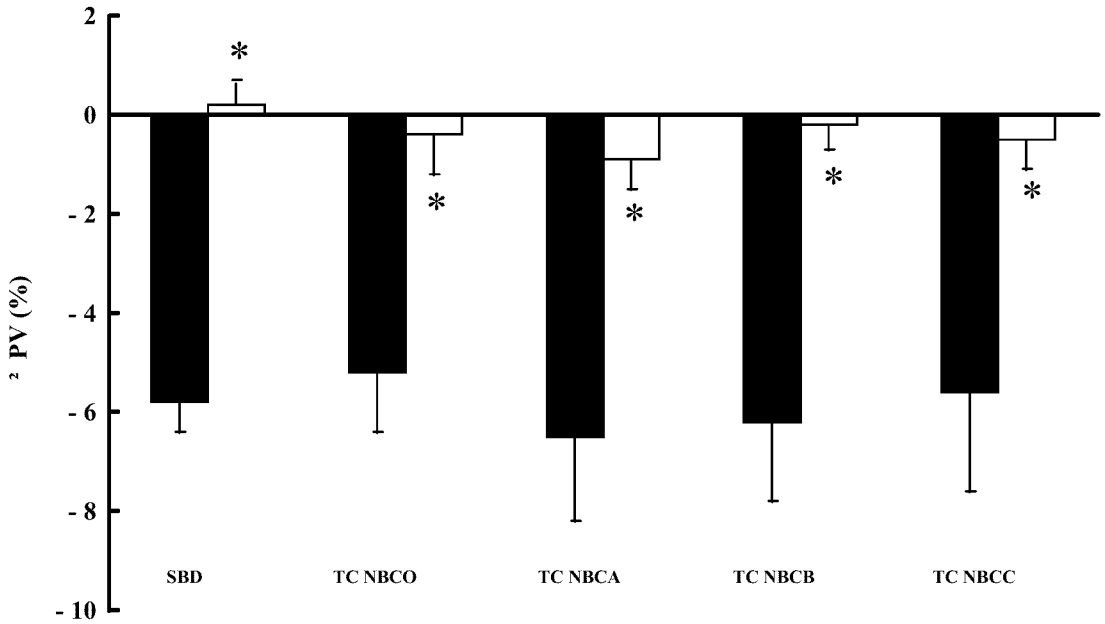

Figure 2 : Plasma volume variation ΔPV (means ± SEM) in six subjects after sustained exercise (.) and recovery (.) with different combat suits : standard battle dress (SBD) and 4 light NBC protective combat suits (TC NBC-O, TC NBC-A, TC NBC-B, TC NBC-C).

* $P<0.05$ compared to exercise values.

During recovery, the amounts of ingested water (through the gas mask) were lower using NBC protective suits (P <0.05) and were insufficient to correct the water losses and plasma volume reductions. The urinary volume was also reduced while osmolality and density increased (P <0.05).

The sustained exercise was performed with similar duration whatever the suits (5 min 20 s to 5 min 50 s). However, the sweat rates were twofold higher with NBC suits than with standard battle dress (P <0.05). The large PV decrease (about -6%) just after the run, whatever the suits, could be rather due to the intensity of exercise than the water losses. Maximal amounts of water ingested through the gas mask after the run were small (about 60 to 90 ml during 30 s) and insufficient to compensate efficaciously the fluid losses.

Conclusion

Our results have shown the importance of the fluid losses when wearing light NBC suits in full protection mode during various exercises in hot country. Rehydration through the gas mask was uneasy and did not allow to compensate effectively the water losses.

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